Inner Shelf Facies Character and Stratal Signatures, Northern California

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LONG-TERM GOALS

Our long-term objective within the STRATAFORM research program is to investigate the processes that lead to the genesis, modification, and burial of fine-scale stratification in continental shelf sediments. Our approach is to: a) sample the continental shelf immediately after events and at closely spaced intervals thereafter, to monitor the shorter term (months to years) changes that modify the distribution and character of event layers and b) examine the preserved stratigraphy in the upper few meters of the seabed to examine the characteristics and fate of event layers over the longer term (10 - 1,000 years).

OBJECTIVES

The objectives of this project include:

1) to identify the results of major flood and storm events on the sedimentology and stratigraphy on the inner continental shelf,

2) to investigate the importance of the inner shelf for the longer term preservation of strata initially deposited during events and the relative contributions of physical and biological reworking to the post-depositional modification of event layers, and

3) to use data from the upper few meters of the seabed to examine the along- and across-shelf variability of event layer character and preservation as applied over decades to thousand-year time scales.

APPROACH

From 1995 through 1998, box cores were collected on the Eel shelf in rapid response to major environmental events. Rapid-response sampling has allowed us to obtain seabed samples immediately following a number of these events. The depositional character of the sediments deposited on the middle and outer shelf after the 1995 events have been described in detail (Wheatcroft et al. 1996, 1997) and some modifications that have occurred to the initial deposit have been described (Drake, in press). The inner shelf had remained an area of uncertainty regarding its importance as an area of fine sediment storage and its potential for storm and flood layer preservation.

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Fine-grained material has been seen to accumulate on the inner shelf immediately following river flooding in 1986, 1989 (Borgeld, 1996) and on a more recent cruise, in March of 1998. Borgeld (1996) previously examined cores on a single transect on the Eel shelf and suggested that the preservation potential of muddy deposits on the Eel shelf was greatest between 42 and 75 meters water depth. In addition, sediment budgets for the Eel shelf have suggested the inner shelf as a possible location where muds are sequestered (ultimately preserved following floods). Work thus far has been able to address the preservation potential on the middle and outer shelf; but the conditions under which these flood deposits are preserved on the inner shelf is still unresolved.

To investigate the inner shelf, slow cores and vibracores were collected on sample transects that had been initially established during the rapid-response sampling. Examination of these cores has been coupled with the examination of CHIRP seismic records that have been collected on the inner shelf by N. Driscoll (personal communication).

WORK COMPLETED

During FY 2000, cores were collected on two cruises: vibracores were collected on a July cruise on the R/V Thompson (TN113) and box cores were collected on the R/V Coral Sea in April (CS0004). In addition, N. Driscoll collected CHIRP seismic profiles on TN113.

RESULTS

The formation, short-term (months to years) modifications, and longer-term preservation (years to centuries) of event deposits

The deposition of sediments associated with river flooding occurred in 1995 and 1997 on the Eel River Shelf, California (Wheatcroft and Borgeld, 2000). The sediment accumulation was best observed north of the river and seaward of the sand-mud transition on the shelf. Flood sediments observed on the shelf immediately after river flooding were short-lived unless rapidly buried. For example, preservation of the 1995 deposits on the mid-shelf was enhanced by their rapid burial by the 1997 flood. Currently, deposits associated with either of these floods are rare on the inner shelf, having not been preserved shallower than 50 meters depth.

The inner shelf (50 meters depth, and shallower) has been sampled more intermittently than the middle and outer shelf, but some conclusions regarding the initial deposition of fine-grained sediments can now be inferred. The character of flood deposits on the inner shelf has generally matched those in deeper water; the sediments are brown in color, have high porosity and are relatively transparent to x-rays. In addition, the newly deposited muds are commonly seen to drape ripple forms. In 1986, Borgeld (1996) encountered muds on the surface of the sediment in depths as shallow as 20 meters; in March of 1998 we encountered surface muds at 30 meters depth. Analyses of sediment size indicate that the recent flood deposits on both the inner and middle shelf have a recognizable size signature when they are initially deposited (Wheatcroft and Borgeld, 2000). These muds have a mean sediment size from 8 to 16 microns with less than 28% coarser than 32 microns. On the inner shelf, the ambient sediments are much coarser. For example, at 30 meters the background sediments have a mean sediment size of 100 microns and more than 94% is coarser than 32 microns.

The ability to recognize older flood sediments by their size allows us to test the possibility that flood sediments have been preserved or incorporated in the inner shelf sands. Vibracores collected from the inner shelf indicate the presence of occasional muddy horizons at depth in the cores. Some of these cores also contain ripple cross-lamination and some ripple forms with mud-drapes. These muds have a mean sediment size ranging from 8 to 16 microns with less than 28% coarser than 32 microns, generally matching the character of modern flood sediments.

The cores that contain older flood-related strata are not randomly distributed on the shelf. The recent vibracoring and high resolution CHIRP seismic profiling appears to have identified a sediment depocenter on the inner shelf, north of the Eel River and landward of the sand-mud transition, where older flood sediments have been preserved. Given that flood-layer preservation in deeper water required rapid burial, flood deposit preservation on the inner shelf must also have required burial immediately following their introduction. This inner shelf depocenter is located north of the Eel River mouth and south of the entrance to Humboldt Bay, from approximately 35 to 55 meters water depth. Flood deposits were encountered in sediment cores collected in this area, but were rarely seen to the north or south.

In this same area, a prominent reflector was encountered about 1 to 1.5 meters below the seabed in the high-resolution CHIRP seismic profiles collected from this area of the shelf (Driscoll et al. 2000). The reflector corresponds to the most prominent flood layers encountered in the cores.

The along- and across-shelf variability of event layer character and preservation as applied over centuries to thousand-year time scales.

The CHIRP seismic reflection surveys (Driscoll, 2000) reveal a thinning of the inner shelf sands from greater than 30 meters thick at the subaqueous Eel delta to less than a meter thickness 10 km north of the Humboldt Bay entrance. Vibracores that were able to reach through the Holocene sands in this region penetrated through an erosional surface characterized by a pebble lag or in some cores, a shell lag. Sediments below the erosional surface exhibit a high level of small-scale variability as older estuarine, fluvial and shallow marine facies were encountered in cores collected within a few kilometers.

The sediments comprising the upper 0.5 to 1 meter of the shelf generally coarsen to the north on the inner shelf, away from the Eel River; sediments deeper in the cores are more uniform along-shelf. The implication is that episodic flooding of the Eel River is the primary source of sediment input and that flood-layer deposition is only preserved on the inner shelf south of Humboldt Bay. Elsewhere along the shelf, the sediments may be deposited for a short period but these sediments are remobilized and transported along shore and accumulate in areas of localized tectonic subsidence.

IMPACT/APPLICATIONS

A better understanding of the conditions, under which shelf sediments are preserved, in an active setting such as the Eel Margin, will undoubtedly lead to a better understanding of shelf sedimentation. The inner shelf is of particular interest as these rocks are commonly used to aid in the interpretation of preserved shelf sequences. The role of tectonics in such sedimentary processes has application to a large proportion of such settings around the globe.

TRANSITIONS

These results are being used by a number of other investigators within the STRATAFORM research program. For example, the understanding and interpretation of high-resolution seismic data has been aided by the analysis of the longer sediment cores. The interpretation of recently collected Multibeam Swath data (Ferrini et al., 2000) will also utilize some of these results in their interpretation. In addition, the recognition of the offshore expression of the Eureka Anticline will aid in the interpretation of the tectonic effects along the northern California coastline and will aid in the evaluation of seismic hazards along the coast.

RELATED PROJECTS

Including some of the projects identified above, related projects include: D. Drake, flood and storm sediment modification over annual time scales (Drake et al., 2000); N. Driscoll, high-resolution CHIRP seismic structure of the Eel Margin (Driscoll et al., 2000); R. Flood, multibeam Swath mapping of the inner Eel Shelf (Ferrini et al., 2000); C. Nittrouer, sedimentary character of the Eel Shelf; R. Wheatcroft, event-scale sedimentary processes on the Eel Shelf (Wheatcroft and Borgeld, in press).

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